THE CALIFORNIA DROUGHT: A QUASI-EXPERIMENTAL ANALYSIS OF SOCIAL POLICY

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The effect of fines for failure to conserve water during the California drought of 1976 to 1978 was evaluated in a retrospectively arranged multiple-baseline design across three San Francisco Bay area cities. The data indicated that, on a community level, significant savings of water occurred regardless of whether fines were introduced or not. However, on an individual level, fines appeared to have an effect on private, as opposed to commercial or industrial, consumers who had received at least one fine. The limitations imposed on these conclusions by the quasi-experimental nature of the design were highlighted. Possible reasons for water conservation in the absence of fines were discussed within the framework of stimulus control. It was suggested that an area for future research should be the delineation of stimulus parameters involved in producing behavior change in entire communities.
DESCRIPTORS: quasi-experimental designs, community behavioral engineering, water conservation, fines, stimulus control, media coverage

The severe drought of 1976-1977, which affected much of the western and midwestern United States (Rosenberg, 1978), presented an unusual opportunity to examine the effects of aspects of public policy that were used to reduce urban water use. Such an opportunity is particularly valuable in an age of increasing shortages of raw materials because the findings may provide insight into the management of crises other than drought.

The San Francisco Bay Area was severely affected by lack of rainfall during the winter of 1976-1977, particularly because the small

amount of rain was accompanied by an extremely low snowpack in the Sierra Nevada, the runoff of which constitutes a major water source for the Bay Area. Figure 1 illustrates the annual pattern of rainfall in downtown San Jose, located at the southern end of the bay. This pattern is typical for the whole area, and therefore representative of the three communities—Hayward, Palo Alto, and Mountain View—that will be studied in this paper. The Spearman rank correlation between the rainfalls of San Jose and Palo Alto was $r = .88$ and between San Jose and Hayward, $r = .94$. San Jose was chosen for this graph because it had the longest continuous record of rainfall available to us. As can be seen in Figure 1, there is a pronounced annual cyclic in monthly rainfall. Large peaks occur during the winter months with almost monotonous regularity, with little or no rainfall in the summer. However, the winters of 1976-1977 are conspicuous due to the large reductions in rainfall. The presence of a drought is also evident in the 1-yr moving average which cancels out annual cyclic variation. Thus, during the years of 1977-1978, the moving average dropped
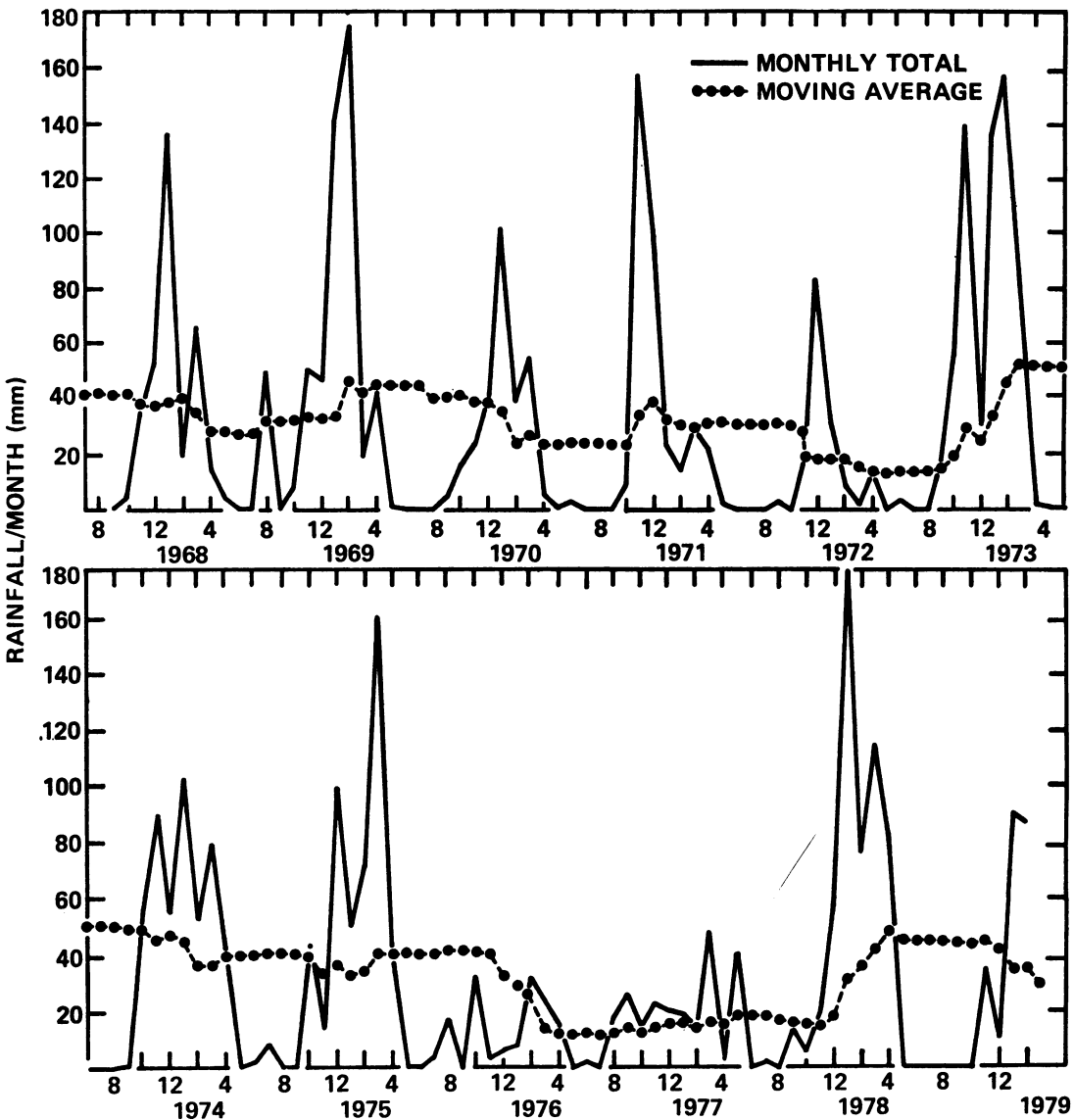
Fig 1. Rainfall per month and 12-mo moving average of rainfall in downtown San Jose, California, 1968-1979.

to a minimum low of 12 mm from a predrought level of 30 to 40 mm.

During the drought, efforts were made in bay area communities to conserve water. Appeals, information, and, in some communities, fines for excessive water usage were used to influence consumers. The use of information, appeals, prompts, and incentives in various combinations has been examined in a variety of contexts relevant to conservation, such as fuel consumption

(Kohlenberg, Phillips, & Proctor, 1976), litter control (Burgess, Clark, & Hendee, 1971; Clark, Burgess, & Hendee, 1972; Geller, Farris, & Post, 1973; Hayes, Scott Johnson, & Cone, 1975) and returning library books to the shelf (Meyers, Nathan, & Kopel, 1977). Taken overall, these studies suggest that information and appeals have little effect in generating behavior leading to conservation, and that incentives are both necessary and effective. On the other hand, in

some studies, appeals have been shown to have at least a small effect as compared with baseline conditions (Geller et al., 1973; Witmer & Geller, 1976).

The California drought allows an examination of the relative effectiveness of appeals versus response cost in somewhat larger populations than are usually studied. Moreover, because these procedures were widely applied during the recent drought and little is known about their effectiveness in large populations (Haas, 1978), the answer to this question may be helpful in guiding social policy in future severe droughts or other crises involving shortages of essential supplies.

The study of a rare and unpredictable natural event poses special research problems. First, because it is difficult to determine the exact onset of an event such as a drought except retrospectively, and therefore it is not possible to plan prospective data collection, the researcher must make do with data compiled for purposes other than research. Although such data sets often have the advantage of being collected unobtrusively, they are usually incomplete. In addition, if several data sets are available but in need of screening for appropriateness before inclusion into the study, researchers run the risk of selectivity by including those sets that tend to confirm their hypotheses. In the present study we were fortunate to have access to data on water consumption in several communities both before and during the drought. However, to evaluate the response during the drought, only those communities with stable baselines (i.e., water consumption during the 3 yr prior to the drought) were selected. This was evaluated *before* the results for the drought were analyzed, and thus the decision to include or exclude a particular community was not influenced by knowledge of outcome.

A second difficulty arising from the study of a natural disaster is that it necessitates rapid action and widespread implementation of corrective measures, imposing practical and ethical constraints on performing experiments on such measures. Thus, the researcher must use quasi-experimental designs. Although the limitations of nonexperimental designs can never quite be overcome, the single subject methodology developed in applied behavior analysis can provide a useful model for the construction of stringent quasi-experimental designs. In the present study, a multiple-baseline design was used to compare water consumption, retrospectively, in three communities which differed in their use of fines. In the terminology of Cook and Campbell (1976) this design might be called an interrupted time series with switching replications and control group design. Our hypothesis was that if fines contributed significantly to a reduction of water consumption, an orderly increase in savings should occur concomitantly with the introduction of the fines.

METHOD

Subjects and Setting

Three communities in close proximity to each other in the San Francisco Bay area (Palo Alto, Mountain View, and Hayward) were selected to provide a retrospectively arranged multiple-baseline comparison of water consumption across communities. These communities were roughly comparable in size: Palo Alto had a total of 1,200 water accounts in a population of 55,000; Hayward 24,000 accounts in a population of 96,000; and Mountain View 12,000 accounts in a population of 55,000. Two of the communities used penalty systems for exceeding water consumption targets, but started them at different times. Hayward instituted its penalty system in April 1977 and Palo Alto started its contingency in August 1977. The third community, Mountain View, did not use penalties.

In addition to the three communities selected, others had initially been considered for inclusion into the study. However, some could not be used because of absence of data; others were excluded after inspection of their baseline data showed falling or rising water consumption

during the three years prior to the drought. In the process of selection, Palo Alto and Stanford were considered first as being examples of one community with fines and one without. When Stanford did not fulfill the criterion of a stable baseline, Mountain View was included. Hayward was included because of the desirability to consider a community that had the penalty system operative over a longer time. Thus, the selection of communities was not random. However, to safeguard against bias, inclusion or exclusion of a community was always done before the water consumption during the drought years was known to the researchers.

Conservation Procedures

The goal of all three communities was to reduce water consumption to at least 75% of the level of water use in the corresponding month of 1976. The actual contingencies applied to individual users differed depending on the type of customer. For example, single-family homes that used less than four units per month (one unit = 100 cubic feet) were exempt from the penalty system, whereas those using 5 to 13 units were required to save 10%; 14 to 22 units, 20%; 23 to 30 units, 30%; and greater than 30 units, 40% of the 1976 consumption for the month. The average consumption for a single-family home was 18 units per month before the drought. For excess use, consumers were to pay twice the base rate for the 2nd to 5th excessive units, three times the base price for the 6th to 10th excessive units, four times the base price for the 11th to 50th excessive units, five times the base price for the 51st to 100th. Similar sliding targets and progressive fine increases were instituted for commercial and industrial water users. Fines were instituted on a monthly basis and could be adjusted, for example, in cases in which a house was inhabited by a greater number of persons than during 1976, when excessive use during a particular month was compensated for by a very low use

in another month, when water-use data showed that a customer had already begun to save water in 1976, or in other cases of "hardship."

In addition to penalties, consumers were pressured from several other sources to conserve water. The base rate per unit of water was increased by 30% to 40%. Social pressure would be exerted by neighbors who occasionally reported water wasting to the water company. Finally, people may have been prompted to save water by experiencing the absence of rain (Figure 1) and seeing the near empty reservoirs, thus providing a confirmation of the presence of a drought independent of reports from the water companies or the news media.

Measures

Water consumption. Monthly data on water consumption for the years of the drought and for the 3 yr preceding the drought were obtained from water departments. The 3-yr period before the drought was used as baseline, and the median of each month over the 3 yr was used as an estimate of what the water consumption would have been if there had not been a drought.

The decision to use the median of 1973-1975 as a predictor was based on an exploratory analysis of the Palo Alto data before data on the other communities had been collected. Initially, a predictor of water use for each month was based on a regression of water consumption on rainfall within each month and across the three baseline years. There was a consistent but small regression of water consumption on a weighted 2-mo moving average of the rainfall (rain of present month + ½ × rain of previous month). The regression coefficient varied over different months, in general being higher in the summer and lower in the winter. To reduce the effect of chance variation, this sequence of monthly regression coefficients was smoothed by medians of 3 (Tukey, 1977, pp. 210-219) before being inserted into a regression formula in which the intercept was determined by the

average water use of the particular month across the baseline years. It turned out that this complex predictor was only minimally better than the monthly medians, thus the latter method was used as a predictor.

Water conservation was measured as the difference between actual and estimated consumption. The Hayward data had to be analyzed bimonthly rather than monthly, as in the other communities, for the following reason: A food-processing factory in Hayward, which accounted for almost 10% of the water consumption, gradually relocated its production a a different county for reasons unrelated to the drought. Statistics on the water use of this plant were accounted separately by the water company but only on a bimonthly basis. Because it was undesirable to use data that largely reflected one individual customer, community water consumption was calculated for 2-mo periods by subtracting the bimonthly water use of the food-processing factory from the total bimonthly consumption.

Index of nonspecific influences. To obtain an index of nonspecific influences to reduce water consumption, the news coverage of the California drought in the *Palo Alto Times* (the daily newspaper for both Palo Alto and Mountain View) was measured. Both the length of the articles and the number of issues per month with drought articles could be considered as important aspects of news coverage. Both were measured, and it turned out that the arcsine transformation of percentage days with drought articles was linearly highly related to a logarithmic transformation of the number of column inches per month written about the drought. The Pearson product-moment correlation was .97. The high level of relatedness indicated that little would be gained by using both variables. Therefore, we used percentage of issues per month with at least one article on the drought as the only index for news coverage, because this measure would be easier to understand than a measure combining transformed scores. Criteria for determining if a news article was dealing with the

drought were as follows: (1) articles explicitly using the word "drought"; (2) articles implicitly referring to the drought by using words such as "rain shortage," "parched," "dry spell," or "lack of water"; (3) articles dealing with water rationing and conservation; (4) articles not primarily dealing with drought but referring to it, i.e., mention of the forest being dry because of the drought in an article primarily covering a forest fire; or (5) editorials, cartoons, and advertisements fulfilling criteria 1 to 4. To determine reliability, a second evaluator examined 10 randomly chosen months for the presence or absence of drought articles in each issue of the *Palo Alto Times* using these guidelines. The point-to-point reliability (across individual days) was kappa $= .72$. The "trial" reliability of the monthly percentage scores, calculated as the Pearson product-moment correlation of the monthly scores of the two observers was $r = .98$.

In addition to general articles on the drought, "appeals" and articles indicating that the "drought was over" were recorded. An "appeal" was defined as any article that explicitly asked the public to conserve water, excluding articles that merely reported on efforts to conserve water without making an explicit appeal. "Drought over" was recorded if this was stated explicitly.

Individual fines (Palo Alto). Data from the Palo Alto water department on individual accounts receiving fines were obtained to determine the effect of fines on this subpopulation. Accounts were subdivided into three groups: large industry, small commercial, and private households. Large industry accounts had already been singled out by the water department in its regular bookkeeping routines; all of the account numbers in this group began with a special 3-digit number. A private household was defined as an account in which the name of the owner indicated an individual person (i.e., identified by first and/or last name). Small industry or business was indicated by an account in which the name of the customer gave such indication, for examples, names of restaurants, apartment com-

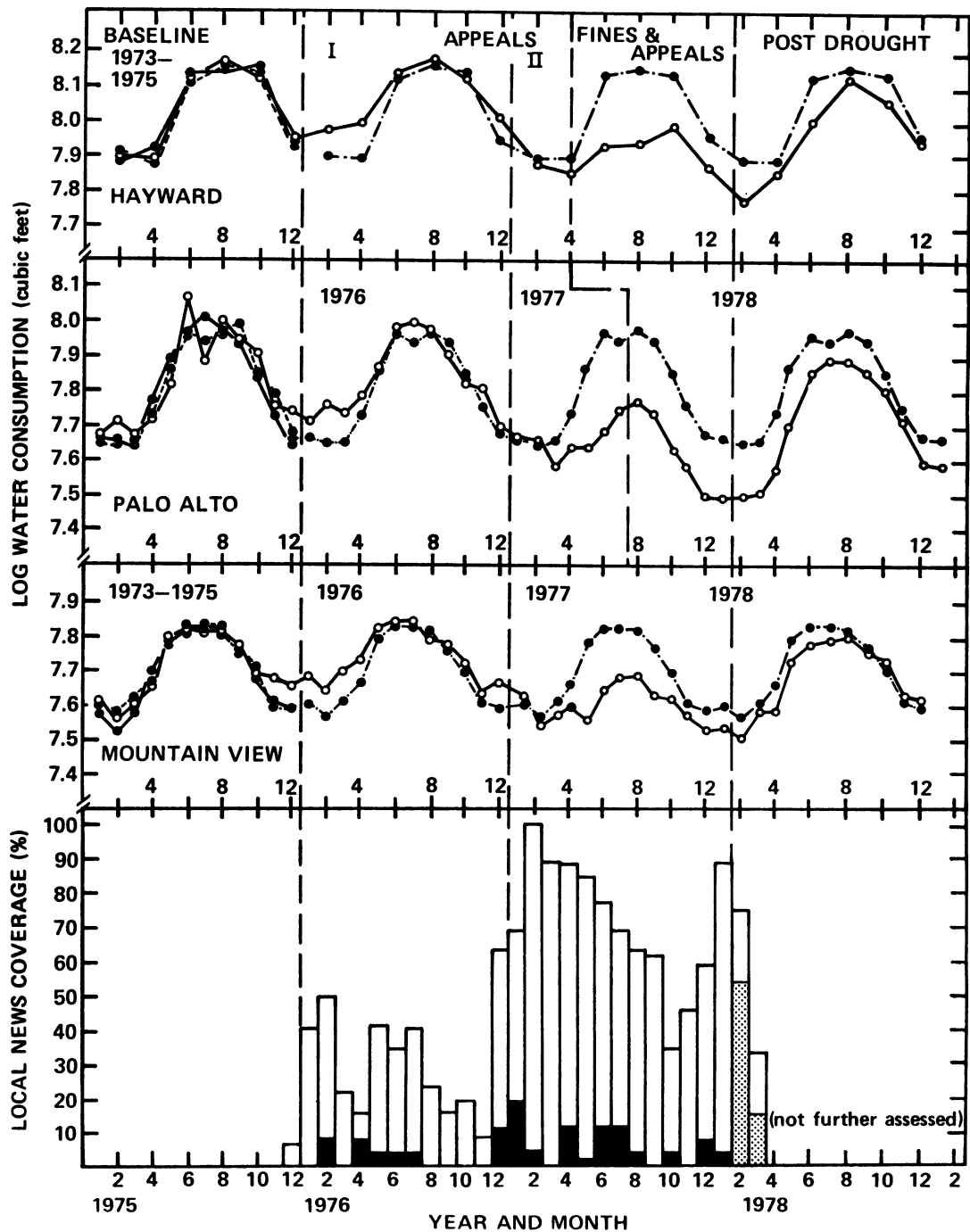Fig. 2. *Upper three-quarters:* Water consumption during baseline, drought, and postdrought in three communities. Dotted line after baseline represents the median of the three baseline years.

Lower one-quarter: News coverage about the California drought, percentage of issues each month with at least one article featuring aspects of the drought. Black bars: appeals to conserve water: gray bars: drought over.

plexes, or "& Co." added after a name. The reliability of the division of private household versus small industries was kappa = .90.

RESULTS

Index of nonspecific influences. The bar graph of the lower part of Figure 2 indicates that although there was news coverage about the drought in December 1975 and January 1976, explicit appeals to save water did not begin until February 1976. By this time the 1-yr moving average of rainfall had fallen to 26 mm (Figure 1), compared with 35 mm in February of the previous year. Because the winter was ending, further significant rainfall was not likely until the next winter. News coverage continued throughout the year, but appeals stopped in August, possibly related to unexpected rainfall in August and September of 18 mm and 26 mm, far above the 104-yr average for these months of 1.4 and 6.3 mm, respectively.

When it did not rain during the second winter, local news coverage and appeals increased to unprecedented levels. The highest level of appeals occurred in January 1977, and the following month every issue of the *Palo Alto Times* included at least one feature about the drought. A high level of news coverage was maintained throughout the year. In April, fines were implemented in Hayward; and in August, fines were implemented in Palo Alto.

The rainfall of 59 mm in December 1977 (see Figure 1) heralded the end of the drought. However, the official position was that water should continue to be conserved, as evidenced by appeals in December and January and by the continuation of fines. January 1978 was characterized by very heavy rains, totaling 180 mm, the highest level of rainfall during the month of January recorded since 1916. On February 4, 1978, the drought was officially declared over. Fines were abolished, and articles indicating that the drought was over appeared in more than half the February issues of the *Palo Alto Times*.

Somewhat arbitrarily, the period 1973 to 1978 may be divided into the following phases in respect to the drought: Baseline, Appeals 1, Appeals 2, Fines, and Post-drought. The three predrought years constitute the baseline period. Appeals 1 began with the first appeals in February 1976. Appeals 2 began in the winter of 1976-1977, as evidenced by the higher level of appeals and news coverage. Fines were implemented only in Hayward and Palo Alto, beginning in April and August 1977, respectively. Finally, the Post-drought phase began in February 1978.

Water consumption. Water conservation was measured as a difference between actual and estimated consumption. Either absolute or relative savings were possible measures, but the latter were preferable because they are not affected by population size. Therefore, a log transformation was made of the water consumption data in Figure 2, so that the difference between the actual and estimated consumption would be an expression of relative rather than absolute savings. Another measure of savings can be obtained by simply expressing the actual consumption as a proportion or percentage of the estimated consumption. These percentage figures are presented in Table 1.

The upper parts of Figure 2 depict the water consumption of the three communities compared with the median for the month during baseline. Water consumption during baseline was closely approximated by the median and showed no consistent rising or falling trend. During 1976 (Appeals 1), water consumption was somewhat *above* the median in all three communities, despite publicity concerning the drought and appeals to conserve water. In contrast, during the first 7 mo of 1977, substantial savings took place in all three communities, despite the fact that only Hayward had implemented fines. In all three communities water consumption dropped to a low of 50% to 60% of the baseline consumption. During the remainder of the year, relative water consumption increased somewhat in Hayward and Mountain View, although the fines remained in effect in the former. Mountain

Table 1

Percent water use compared to baseline for Mountain View (M), Hayward (H), and Palo Alto (P).

	1976			1977			1978		
Month	M	H	P	M	H	P	M	H	P
January/February	120	118	120	102	100	100	87	. 76*	69*
March/April	120	128	118	89	90	83	89	93	70
May/June	106	102	104	64	62*	56	89	78	72
July/August	99	106	108	74	61*	64*	94	95	85
September/October	104	98	93	79	71*	62*	102	84	87
November/December	114	115	109	90	84*	67*	104	102	88

*Water use during fine contingency.

View increased somewhat more than Hayward, the only difference favoring fines apparent in this three-community comparison of water consumption data.

During the post-drought year, relative water consumption continued to remain below 100% for a considerable time in all three communities, despite the fact that public appeals and contingencies were removed. In Palo Alto, water consumption never quite returned to baseline.

Individual fines. Information was available on the amount of the fine and the month the fine was levied. Customers whose fines were negotiated were excluded from further analysis. Because the amount of the fine progressively increased the higher the excess of water consumption had been, the level of the fine served as an index of both the severity of the "punishment" and the level of the water consumption compared with the same month in the previous year.

If fines were effective, a higher fine would more likely be followed by a low or no fine the following month. If, on the other hand, fines were not effective, a random pattern of movement or a stability of fine levels across months would be expected. Fine movements were evaluated by creating a matrix in which the level of fines of the month in consideration was on the vertical axis and the level of fines of the same account in the next month on the horizontal axis (see Table 2). Stability was evaluated using the kappa coefficient (Fleiss, 1973, pp. 146-147), and nonrandomness in the pattern of movement

was evaluated statistically with the McNemar test (Fleiss, 1973, pp. 73-74).

Table 2 a-c depicts the fine movements of private, large industry, and small commercial accounts in Palo Alto (comparable data were not available for Hayward). For example, in Table 2a, 20 private accounts fined at the level of $1-3 a particular month, remained in this fine category the next month, whereas 10 received a higher fine and 246 received no fine the next month. The numbers in parentheses are the expected numbers, as calculated from the marginal sums. Statistical analysis of private accounts indicated that there was no stability of fines (kappa = .03). In addition, more went down than went up (438 down vs. 342 up, $\chi^2 = 11.57, p < .01$). This would argue in favor of fines having an effect on this group. For large industrial accounts kappa was .23, indicating a greater stability of fines across months. In addition, about the same number of decreases as increases were noted (219 down vs. 240 up, $\chi^2 = .87$, N.S.). This indicates that fines were unlikely to have been effective in this group. Finally, for commercial accounts, kappa was .08, indicating a low level of stability. However, about the same number of decreases as increases were noted (279 down vs. 248 up, $\chi^2 = 1.71$, N.S.). This indicates that fines were not effective in this group.

The total number of private and commercial accounts fines was approximately 3,200 or close to 20% of all accounts in this category. In contrast, 200 of the 700 large industrial accounts or 30% were fined at least once.

Table 2

Fine Movements of Palo Alto Water Accounts

A. Private

		NEXT			
		0	1-3	4-	SUM
P R E S E N T	0	1,352 (1,374)	203 (181)	129 (129)	1,684
	1-3	246 (225)	20 (30)	10 (21)	276
	4-	181 (180)	11 (23)	28 (17)	220
SUM		1,779	234	167	2,180

B. Large Industrial

		NEXT				
		0	1-11	12-50	51-	SUM
P R E S E N T	0	454 (398)	63 (68)	74 (100)	57 (82)	648
	1-11	55 (68)	33 (12)	20 (17)	3 (14)	111
	12-50	77 (98)	12 (17)	49 (25)	22 (20)	160
	51-	56 (77)	1 (13)	18 (19)	51 (16)	126
SUM		642	109	161	133	1,045

C. Commercial

		NEXT				
		0	1-3	4-11	12-	SUM
P R E S E N T	0	710 (697)	91 (95)	75 (74)	64 (73)	940
	1-3	112 (107)	22 (15)	8 (11)	2 (11)	144
	4-11	85 (88)	13 (12)	13 (9)	8 (9)	119
	12-	56 (71)	6 (10)	7 (8)	28 (8)	97
SUM		963	132	103	102	1,300

DISCUSSION

Because the onset of water savings did not coincide with the introduction of fines across communities, this study does not provide strong support for the efficacy of fines in this particular case. The largest water savings occurred during the 2 mo *before* fines were introduced in Palo Alto, indicating that other variables were effective in producing water savings, and that fines added little to the effect. The lack of immediate reversal after cessation of fines and the lack of effect upon the fine movements of industrial and commercial accounts also pointed in the same direction. On the other hand, comparing Mountain View, the community without fines, to the remaining communities, the overall savings were somewhat less in the former during the later months of the drought. This lends some support to an argument that fines were at least somewhat effective, and the fine movements of private accounts are in agreement with such a proposition.

As is the case with any quasi-experiment, the final conclusion will not be entirely dictated by the data but also by the subjective estimates of the researcher concerning the plausibility of alternative explanations. It should be emphasized, however, that if water consumption had been found to decrease in orderly fashion after the onset of fines, explanations attributing this change to other variables would have seemed farfetched. In such a case, the study would have made a strong argument for the efficacy and necessity of fines. Weighing the actual evidence of this study, however, we conclude that fines were not essential for savings and added little to voluntary conservation. Reasons for this may be that the fines were not high enough and that the voluntary efforts reduced consumption to such a low level that further reduction could not occur without considerable hardship. Does this imply that water departments should be advised not to employ penalties in future droughts? Because the water conservation programs in all the communities were successful, there may be no reasons for significant departures in the future. One might speculate, however, that should large savings be desired, an increase in the level of fines might be tried as a component of the intervention program.

A puzzling question remains: What factors were responsible for the remarkable savings in water consumption? Here some speculations may be warranted. Comparing the first to the

second year of the drought, it is remarkable that no savings occurred in the first year despite a moderate level of nonspecific influences such as appeals and news coverage. In fact, water consumption *increased* somewhat, probably in response to the lack of rain. During the second year, the level of nonspecific influences rose to a much higher level, after which water consumption declined drastically. Thus, water consumption may have responded to stimulus rather than outcome control (Bandura, 1969).

If the decline in water consumption was a result of stimulus control, it seems important to attempt to delineate which aspects of the stimulus configuration are essential for the effect. It is common knowledge that when people are influenced to rally behind a cause and drastically change their behavior, there is the common perception of the presence of a "crisis." Such a "crisis stimulus" may be produced by the combination of consistent input of high intensity from multiple independent sources. In the case of the drought, stimuli from highly diversified sources, such as daily news coverage of the drought, lack of rain, dry land, dry vegetation, and empty water reservoirs, converged on a simple internally coherent message indicating the presence of a drought-crisis, and this was hammered in day after day. In contrast, compared to the second year of the drought, the first year was characterized by a lower intensity of influences, some of which were conflicting with one another. An example of conflicting stimuli was the unusually high rainfall level of August 1977, and occasional speculations in the press that the drought was "invented" in order to raise the water rate.

These considerations lead us to conclude that in future research, attention needs to be directed toward delineating the stimulus elements that distinguish a "crisis" from "no crisis" in addition to directing attention to the contingency management of behavior.

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